10/031934
PCT/AU00/00894

REC'D 28 AUG 2000
WIPO PCT

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Patent Office
Canberra

I, KAY WARD, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PQ 1894 for a patent by TENIX DEFENCE SYSTEMS PTY LTD filed on 28 July 1999.

AU 00/00894

WITNESS my hand this
Twenty-first day of August 2000

KAY WARD
TEAM LEADER EXAMINATION
SUPPORT AND SALES

P/00/009
Regulation 3.2

ORIGINAL

AUSTRALIA
Patents Act 1990

PROVISIONAL SPECIFICATION FOR THE INVENTION ENTITLED:

IMPROVEMENTS IN OR RELATING TO VEHICLES

The invention is described in the following statement:

IMPROVEMENTS IN OR RELATING TO VEHICLES

FIELD OF INVENTION

The present invention is directed to improvements in or relating to vehicles and structures, and is more particularly directed to methods for reducing the radar signature of structures by directing the radar reflections from structures away from specified directions.

BACKGROUND TO THE INVENTION

Air-borne and water-borne defence vessels are under constant threat of detection and possible attack from non-friendly artillery such as ground-based, sea-going or air-borne weapons systems. Vessel detection is usually by means of radar, since conventional vessels, to a greater or lesser extent, all possess a radar signature.

Radar operates by transmitting a pulse of electromagnetic energy and measuring the time between the transmitted pulse and the receipt of the reflection of the pulse from a target. The range at which a target can be detected is a function of, amongst other things, the intensity of the pulse energy and the size of the target (also known as radar cross-section) with respect to the frequency of operation of the radar. In its simplest form, the best return of the electromagnetic pulse to the radar is generated when the surface reflecting the pulse is normal to the direction from which the pulse is transmitted. In this example, the strength of the return signal is proportional to the square of the area of the surface and the square of the radar frequency.

A number of proposals have been put forward with a view to reducing the radar signature of such vessels. In general these proposals involve purpose-building the vessel with radar cross-section reduction capability. This involves, in the case of a water-borne craft, shaping the hull and other components of the craft. One such design is the so-called "stealthy" vehicle. These vehicles are designed so that the shape reflects radar energy away from the threat sectors into more benign areas.

For example, an F117 bomber's threat region is forward and below the aircraft. Hence design is such that energy from a radar signal is reflected upwards and sideways from its angled surface facets. Stealth ships require protection from sea-skimming missiles which normally approach parallel with the sea surface. Such a ship therefore has sloping sides which reflect the radar energy upwards and away from the threat direction.

It will be appreciated that vessels incorporating such designs involve significant expense over and above the basic vessel. With tightening of government spending generally and defence budgets specifically, the prospect of replacing an ageing fleet with a new fleet which incorporates

an expensive design, even if the design may reduce the likelihood of loss of the vessel when on a war footing, is not an attractive proposition.

For vehicles that are not designed as "stealthy", the usual method of treatment to reduce radar cross-section is to cover the vehicle with a radar absorbent material. These materials are usually electrical attenuators such as carbon granules embedded in a membrane that is then fastened to the vehicle. This material works by attenuating the signal as the pulse energy passes through it towards the reflecting surface, and then again after reflection so that the resulting return signal is reduced. Radar absorbent materials of this type are expensive to purchase and install, and create major maintenance problems by trapping moisture and dirt and promoting corrosion of the substrate such as the ship super structure. Other proposals for radar absorbency have included the use of absorbent rubber sheets and paints.

SUMMARY OF INVENTION

The present invention accordingly provides in one embodiment a method for retrofitting a vessel to reduce its radar signature, the method including the step of attaching to surfaces of the vessel superstructure an array comprising a plurality of elements, the elements having reflective surfaces with substantially planar faces, the arrangement being such that when attached to surfaces of the vessel superstructure the faces are oriented so as to reflect an incident radar signal in a direction away from its direction of incidence for a given range of incident directions.

The present invention provides in another separate embodiment an array when used for retrofitting a vessel to reduce its radar signature, the array adapted to be fastened to surfaces of the vessel superstructure and comprising a plurality of elements, the elements having reflective surfaces with substantially planar faces, the arrangement being such that when the array is fastened to the vessel superstructure the faces are oriented so as to reflect an incident radar signal in a direction away from its direction of incidence for a given range of incident directions.

The present invention provides in another separate embodiment a vessel having surfaces of its superstructure retrofitted with an array according to the invention.

The orientation of the faces is preferably such that the faces are oblique to the direction of incident radar for a given range of incident directions. Preferably any edges defining the boundary of the reflective surfaces are also oriented so as to be oblique to the direction of incident radar. In this embodiment of the invention, with a surface orientation that is oblique to the direction of incident radar, the strength of the return signal is then only proportional to the square of the edge of the surface normal to the incident radar. If the face is oblique to the direction of incident radar, and the edges of the surface are oblique to the direction of incident

radar, then only the corners of the surface will reflect as point sources. As points have no spatial dimension, the strength of the return signal from each point will vary inversely with the square of the radar frequency. In this way the radar cross-section of the vessel, and hence its radar signature, can be reduced for a given range of incident radar directions.

The present invention is capable of providing a degree of control over the direction in which electromagnetic waves are redirected, permitting other directions as well as the incident direction to be avoided where required.

A vessel according to the invention is any ship or vehicle requiring defence against radar threat. A vessel superstructure according to the invention includes any surface on the vessel capable of reflecting a radar signal. The superstructure will therefore, in the case of a water-borne craft, include the hull, bulkhead, decking, the bridge, any weapons or weapon turrets, and rigging.

In the case of a water-borne craft, incident radar is generally parallel to the sea surface, although naturally in some cases incident radar will emanate from aircraft. In accordance with the invention the reflective surfaces are preferably oriented so as to reflect an incident radar signal by up to about 15 degrees more typically by up to about 8 to 10 degrees away from its direction of incidence for a given range of incident directions.

A surface to which an array according to the invention is attached will include substantially vertical surfaces, substantially horizontal surfaces, surfaces disposed at an angle to the vertical, and curved surfaces.

An element according to the invention may take any suitable form. The element will typically be triangular, polyhedral, pyramidal or prismatic in shape or in cross-section. The element may be an elongated triangle, polyhedron or pyramid. The element may be open-sided. It may be a solid figure. Where an element according to the invention defines an apex, the apex will typically be disposed in a region which is forward (colinear with respect to the incident radar signal) relative to the planar faces of the reflective surfaces.

An array according to the invention may take any suitable form. It may be uniform or non-uniform. If uniform, the array may comprise a grid of uniformly spaced elements having reflective surfaces with substantially planar faces. If non-uniform, the array may comprise a plurality of randomly arranged elements having reflective surfaces. The elements may be uniform or non-uniform in shape or cross-section as required.

The arrangement of elements and/or the manner of installation of the array on a vessel superstructure is preferably such that the facets of the elements reflect the incident radar signal

away from the threat direction. The arrangement is also preferably such that the facets of the elements do not provide to any appreciable internal reflection sources whereby to reduce the likelihood of an incident radar signal being reflected towards an adjacent element in the array and in turn reflected back in the direction of the incident radar signal.

The array arrangement may be such that planar faces of the reflective surfaces of the elements are not all arranged in parallel planes.

An array according to the invention is preferably formed from a lightweight material so as to not substantially increase the overall weight of the vessel. The array may be in the form of a cladding. The array may include perforations for the purpose of reducing its overall weight. The size and distribution of the perforations will be dependant on the frequency of the defined threat. The perforations may comprise elements according to the invention. A typical lightweight and relatively inexpensive material suitable for use in retrofitting methods according to the invention comprises aluminium. The aluminium may comprise a foil. The array may in an alternative embodiment be formed from a mesh, such as a woven mesh. The mesh will be suitably treated so as to present substantially planar faces. Other materials such as bronze, stainless steel and copper may be used for forming an array according to the invention are envisaged with the scope of the present invention.

The array may be provided in roll form capable of being cut to facilitate ease of attachment of the array to the vessel. It may be provided in sheet form. The sheet may include stiffening to enhance its rigidity or resilience. The sheet may be elongated. In one embodiment the array comprises a plurality of elongated sheets. The sheets may be joined together in any suitable manner. In another embodiment the array comprises a plate or plurality of plates. The plates may be joined together in any suitable manner.

The array is preferably of relatively small thickness. A typical array thickness is in the range of from about 0.25 mm to 15 mm more preferably in the range of from about 1 mm to 6 mm.

An element may be formed on or in the array by pressing, impressing, stamping, casting, extrusion or by other suitable means to create the desired substantially planar face for a reflective surface of the element.

An array according to the invention may be attached to the vessel superstructure in any suitable manner. The array may be screwed, welded or otherwise fastened to the superstructure. If welded, the array may be stud welded to the superstructure and secured by means of screws.

The screws may be concealed from a given range of incident directions. Other attachment arrangements are envisaged within the scope of the invention.

The array may be releasably attachable to the vessel. This may facilitate ease of maintenance of the vessel superstructure and/or replacement or modification of the characteristics of the array.

The present invention provides in another separate embodiment a method for retrofitting a building structure to reduce its radar signature, the method including the step of attaching to surfaces of the building structure an array comprising a plurality of elements, the elements having reflective surfaces with substantially planar faces, the arrangement being such that when attached to surfaces of the structure the faces are oriented so as to reflect an incident radar signal in a direction away from its direction of incidence for a given range of incident directions.

The present invention provides in another separate embodiment an array when used for retrofitting a building to reduce its radar signature, the array adapted to be fastened to surfaces of the building and comprising a plurality of elements, the elements having reflective surfaces with substantially planar faces, the arrangement being such that when the array is fastened to the building the faces are oriented so as to reflect an incident radar signal in a direction away from its direction of incidence for a given range of incident directions.

The present invention provides in another separate embodiment a building having surfaces retrofitted with an array according to the invention.

A building according to the present invention may include a permanent or temporary structure.

The present invention provides in one particularly preferred embodiment a method for retrofitting a vessel to reduce its radar signature, the method including the step of fastening to surfaces of the vessel superstructure in elongated sheet form an array comprising a plurality of uniformly shaped elements being triangular, polyhedral, pyramidal or prismatic in shape and having reflective surfaces with substantially planar faces, the orientation of the faces and edges defining the boundary of the reflective surfaces being such that the faces and the edges are oblique to the direction of incident radar for a given range of incident directions, the arrangement being such that when fastened to surfaces of the vessel superstructure the reflective surfaces are oriented so as to reflect an incident radar signal by up to about 15 degrees away from its direction of incidence for a given range of incident directions.

The present invention provides in another particularly preferred embodiment an array when used for retrofitting a vessel to reduce its radar signature, the array adapted to be fastened

to surfaces of the vessel superstructure and comprising a plurality of uniformly shaped elements being triangular, polyhedral, pyramidal or prismatic in shape and having reflective surfaces with substantially planar faces, the orientation of the faces and edges defining the boundary of the reflective surfaces being such that the faces and the edges are oblique to the direction of incident radar for a given range of incident directions, the arrangement being such that when the array is fastened to surfaces of the vessel superstructure the reflective surfaces are oriented so as to reflect an incident radar signal by up to about 15 degrees away from its direction of incidence for a given range of incident directions.

BRIEF DESCRIPTION OF PREFERRED EMBODIMENT

The present invention will now be described with reference to our particularly preferred embodiments, in which:

Figure 1 is a schematic of the reflection pattern of a vessel without an array according to the invention;

Figure 2 is a schematic of the reflection profile of the bulkhead of a vessel superstructure to which one element of an array according to the invention is attached; and

Figure 3 is a cut-away perspective view of a side of a vessel to which an array according to the invention has been attached.

Turning to the drawings, Figure 1 shows a vertical surface 14a comprising, symbolically, a bulkhead of a vessel superstructure. In this arrangement a substantially horizontal incident radar signal (designated in Figure 1 as "pulse energy") striking vertical surface 14a (being normal to the incident radar signal) is reflected from the vertical surface 14a directly back to the radar source (not shown). It will be appreciated that a consequence of this arrangement is that the surface by virtue of its cross-section produces an easily discernible radar signature.

Figure 2 shows symbolically a bulkhead 14b to which an array 10 has been attached. Array 10 comprises a plurality of elements (of which for convenience only one typical example designated 15 is shown in cross-section in this embodiment). The element 15 shown is triangular in cross-section and comprises reflective surfaces having substantially planar faces 11, 12 and a leading edge 13. It can be seen from this embodiment that the planar faces are oriented so as to be oblique to the horizontal direction of the incident radar (also designated in Figure 2 as "pulse energy"). Although not clearly shown in Figure 2, edge 13 can also be oriented so as to be oblique to the horizontal direction of the incident radar.

Figure 3 shows part of an array 10 having a pair of elements 15 attached to the vertical surface of a bulkhead in the form of a ship's side 14b by concealed fastenings (that is, concealed from a given range of incident directions) in the form of screws 17.

Accordingly an incident radar signal 20 in a horizontal direction will be reflected in a direction 21 away from its direction of incidence on striking a planar face 11 or 12 of element 15. The angle of incidence of a reflected signal striking another part of the vessel superstructure, or the sea or ship deck 16 in the case of a water-borne craft will correspondingly be the same. The angle of reflection of the incident radar signal is preferably up to about 15 degrees away from the direction of the incident radar signal as shown in Figure 2. By contrast, the untreated upper vertical surface of the ship's side 14b will reflect incident radar signal 20a directly back in the direction of its direction of incidence as that surface is normal to the direction of the incident radar signal 20a.

It will accordingly be appreciated that an array arrangement comprising a plurality of elements 15 is such that when attached to surfaces of the vessel superstructure the reflective surfaces 11, 12 of the elements 15 are oriented so as to reflect an incident radar signal in a direction away from its direction of incidence for a given range of incident directions. There is also a degree of control over the direction in which the electromagnetic waves are redirected, permitting other directions as well as the incident direction to be avoided, where required.

In use, and with reference to Figures 2 and 3, an array 10 in elongated aluminium sheet form comprising a plurality of shaped elements 15 of triangular cross-section and having reflective surfaces with substantially planar faces 11, 12 stamped, embossed, cast or otherwise formed thereon or therein is fastened to a vessel superstructure by stud welding following by securing with concealed fastenings in the form of screws 17. The orientation of the reflective surfaces and edges 13 defining the boundary of the substantially planar faces 11, 12 is such that the reflective surfaces and the edges are oblique to the direction of incident radar for an incident horizontal directions, the arrangement being such that when fastened to surfaces of the vessel superstructure the reflective surfaces are oriented so as to reflect an incident radar signal by up to about 15 degrees away from the horizontal.

The present invention accordingly provides a cost-effective method for reducing the radar signature of an existing vessel and avoids the need to replace an existing vessel with an expensive purpose-built vessel.

The word 'comprising' and forms of the word 'comprising' as used in the description and in the claims does not limit the invention claimed to exclude any variants or additions.

Whilst it has been convenient to describe the present invention in relation to particularly preferred embodiments, it is to be appreciated that other constructions and arrangements are considered as falling within the scope of the invention. Various modifications, alterations, variations and/or additions to the constructions and arrangements described herein are also envisaged as falling within the scope of the present invention.

DATED THIS 28th day of July 1999

McMASTER OBERIN ARTHUR ROBINSON & HEDDERWICKS
Patent Attorneys for
TENIX DEFENCE SYSTEMS PTY LTD

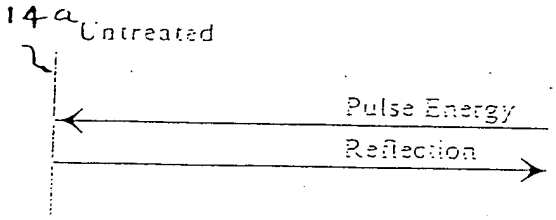

FIGURE 1

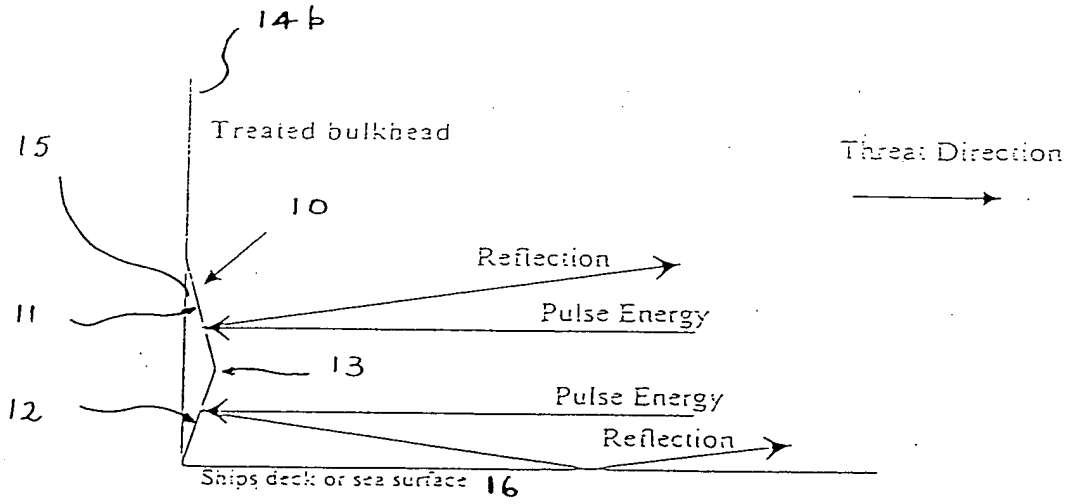

FIGURE 2.

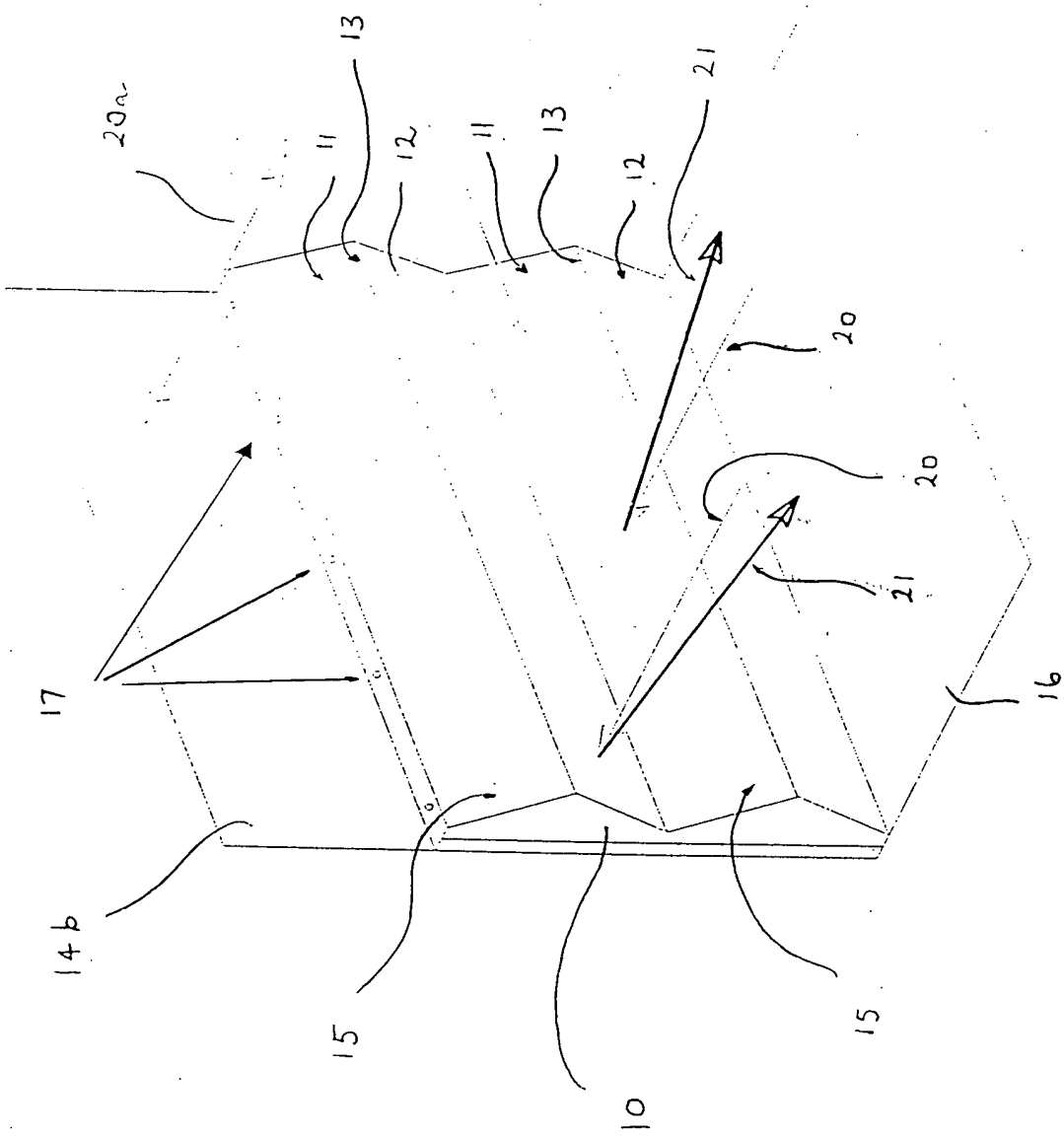

Figure 3.